2025 Jurnal Kejuruteraan, Teknologi dan Sains Sosial
Journal of Engineering, Technology and Social Science
Volume 11 Issue 1 2025, e-ISSN: 27166848

DESIGN AND DEVELOPMENT OF SMART FLOOD DETECTION AND MONITORING SYSTEM WITH IOT BLYNK APPLICATION

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ARTICLE INFO

Article history:
Received
06 October 2024
Received in revised form
05 November 2024
Accepted
06 November 2024
Published online
01 June 2025

Keywords:
flood detection; Blynk application; Wemos, Internet of Things (IoT)

ABSTRACT

The natural phenomenon of flooding has received global attention because of its detrimental effects on civilization. One of the most common natural disasters in Malaysia is flooding, which occurs practically every year, especially during the monsoon season. Therefore, the installation of a flood warning system as a measure to monitor areas that frequently flood and early notification messages to the local community to avoid loss of property and life is very important for areas that often attack. An early flood detection and monitoring system through the Internet of Things (IoT) was proposed and developed in this research to notify people of approaching floods. People are protected from the consequences of flood disasters and given enough time to prepare for future floods with effective real-time monitoring of flash floods or overflows. The results of this project show that if the distance between the ultrasonic sensor and the water level is still more than 50m, then the water level is still low. If the water level is less than 50 cm, it is considered precautionary. Finally, a water level of less than 10 cm indicates that the water level is in danger of flooding. The purpose of temperature and humidity sensors is to identify, measure and record the amount of humidity and air temperature in the surrounding area. A device to detect rain is a raindrop sensor. In conclusion, this innovation project stands out through its portable design, low cost, freedom of internet connection, and the ability to provide flood warning information to support the Automated Weather System (AWS).

1. Introduction

Floods have become more common in many locations, wreaking harm on human lives and livelihoods. Rivers may flood if the flow rate is higher than the capacity of the channel, especially around bends or meanders (Isia at al., 2023; Khan et al., 2020). Floods have become more common in many locations, wreaking havoc on human lives and livelihoods (Khayyam, 2020; Romali et al., 2018). Flood-prone zones cover 9% of Malaysia's geographical area, and 4.8 million people reside there (Rosmadi et al, 2023; Romali & Yusop, 2021). Peninsular Malaysia's beaches are the most prone to flooding, particularly during the northeast monsoon season, which runs from October to March. On December 16, 2021, a tropical depression made landfall on Peninsular Malaysia's eastern coast, pouring torrential rain over three days. The subsequent floods hit eight states on the peninsula, killing at least 54 people and leaving two missing. At its peak, it displaced around 71,000 individuals and affected over 125,000 people overall (Ziarh et al., 2021).

Flooding in Malaysia is caused by both natural and human forces (Taib et al., 2016). Malaysians have always lived along the banks of the peninsula's major rivers (Ziarh et al., 2021). Floods have become a recurrent aspect in the life of many Malaysians, thanks to natural reasons such as strong monsoon rainfall, severe convective rainstorms, inadequate drainage, and other local conditions (Maqtan et al., 2022). The frequency of floods in Malaysia will increase yearly due to the lack of early flood detectors. Besides that, it is also due to a lot of garbage in our ditch. This is because the drainage system in Malaysia is not entirely focused. In terms of waste, most residents make garbage on average. Flooding will occur if the ditch is clogged with a large amount of sewage. In addition, it will cause many people to lose their homes due to their homes being inundated by heavy water. Some houses are also damaged because they cannot withstand a lot of water. In turn, these floods caused the deaths of many residents (Romali et al., 2018; Do et al., 2015).

Therefore, an early flood detection and monitoring system with the Internet of Things (IoT) was proposed and developed in this research. This proposed innovation project is an intelligent system that analyses a variety of natural factors to foresee a flood, allowing communities to take preventative measures to limit flood damage. Natural catastrophes such as floods may be disastrous, causing property damage and loss of life. The system supports Wi-Fi connectivity. Thus, gathered data may be conveniently accessible from anywhere via IoT. The system includes a DHT22 Digital Temperature Humidity Sensor for sensing changes in humidity and temperature.

2. Methodology

2.1 Design of Flood Detection and Monitoring System via IoT

Figure 1 depicts the block design of an IoT-based early flood detection and monitoring system. WeMos D1 R1 is a board based on the ESP 8266, a wifi communication IC designed to resemble the Arduino Uno. However, in terms of specs, it far beats the WeMos D1 R1. This self-contained microcontroller is easy to program using the Arduino IDEAn ultrasonic sensor determines the spacing of two objects by emitting ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that provide information about an object's vicinity. As high-frequency sound waves bounce off of things, different echo patterns emerge. Sound waves are produced by ultrasonic sensors at frequencies greater than those that are audible to humans. Similar to a microphone, the transducer on the sensor receives and sends ultrasonic functions, including ultrasonic sound. Similar to many other sensors, ultrasonic sensors send and receive a pulse through a single transducer (Wee & Keong, 2022). By measuring the amount of time that passes between transmitting and receiving an ultrasonic pulse, the sensor determines the distance to a target. All that is needed for a raindrop sensor is a board covered in nickel lines. It is predicated on the idea of resistance. When the humidity threshold is achieved, the Rain Sensor module transmits a digital signal. It does this by using the analogue output pin to measure humidity. Hew et al. (2022) describe the LM393 Op Amp as the basis for this module.

The DHT-22 is a digital temperature and relative humidity sensor. The DHT-22 sensor measures the ambient air and outputs a signal on the data port using a capacitor and thermistor (Ahmad et al., 2021). The DHT-22 is said to have high reading quality, as seen by the quick responsiveness of the data-collecting process, its small size, and its affordable price. DHT-22 is a sensor that measures temperature and relative humidity and outputs a digital signal. It has four pins: a power supply, data signal, null, and ground (Hidayat et al., 2023). An electronic device that transforms electrical oscillations into sound waves is a buzzer. Since a buzzer and a loudspeaker operate on nearly the same principle, both devices include a coil fastened to the diaphragm. After that, energy is applied to the coil to turn it into an electromagnet. The diaphragm is positioned on top of the coil, and it moves back and forth with each movement of the coil. Depending on the magnet's polarity and the direction of the current, the coil may be pulled in or out. Usually, a buzzer is employed to signal the completion of a process or the occurrence of a device malfunction.

According to Seneviratne (2018), Blynk is a mobile OS application platform for both iOS and android that aims to control Arduino, Raspberry Pi, ESP8266, WeMos D1, and other comparable modules via the Internet. This application lets developers design aesthetically pleasing graphical user interfaces for projects that can only use the drag-and-drop widget technique. It only takes a few minutes, roughly, to set everything up. With this application platform, the user can remotely control everything at any time, from any place. This system is referred to as the Internet of Things (IoT), albeit it should be noted that it is only connected to the Internet via a dependable connection.

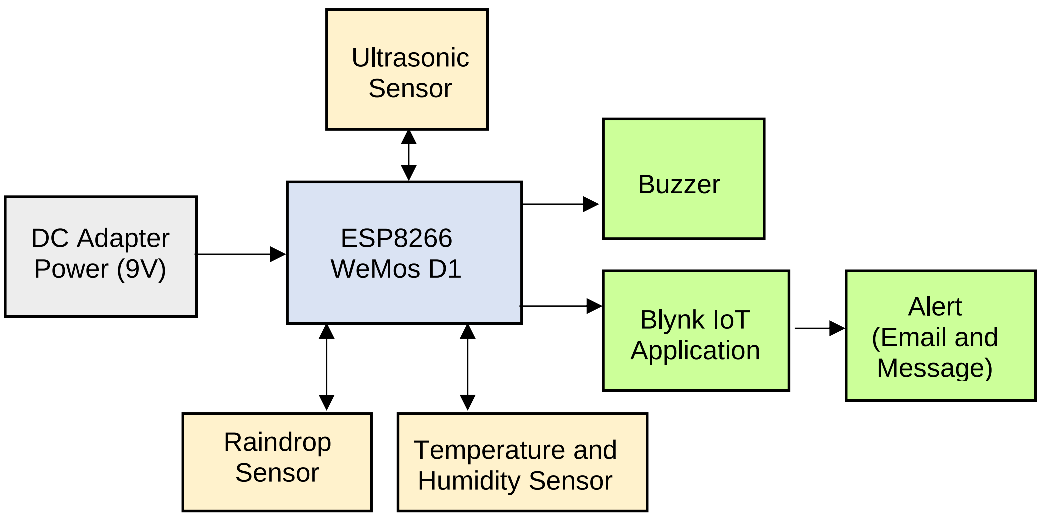

Figure 1. Block diagram for the proposed system.

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2.2 Hardware Development

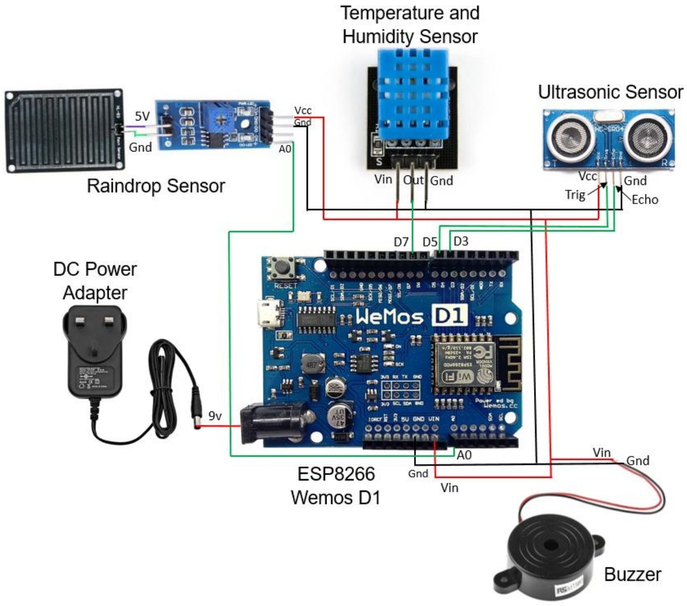
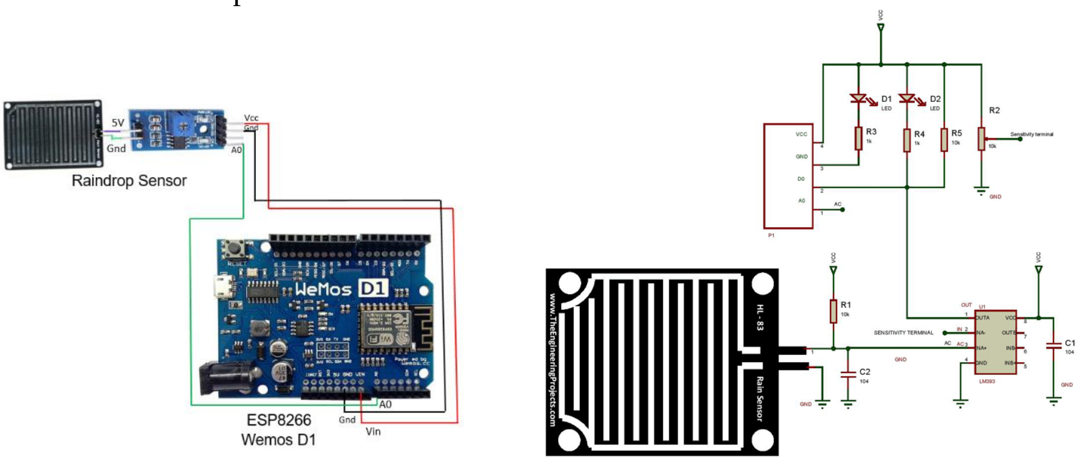


Figure 2. Experimental setup for flood detection and monitoring system

Figure 2 depicts the experimental setup for the Flood Detection and Monitoring System using the Wi-Fi ESP8266 development board WeMos D1. A Wi-Fi development board called WeMos D1 is built around the ESP8266 12E. Apart from the hardware being based on the Arduino UNO, the functionality is similar to that of NodeMCU. You can configure the D1 board to operate in an Arduino environment by using Boards Manager. WeMos functions as a brain to provide information via Wi-Fi and IoT. The raindrop sensor measures the amount of rain that fell on the day of the incident. The raindrop sensor is connected to the WeMos Board, as shown in Figure 3(a). Pin A0 from the raindrop sensor is connected to Pin A0 WeMos Board. The WeMos board supplies 5V to power the raindrop sensor. Figure 3(b) shows the schematic diagram for the raindrop sensor.



(a) (b)

Figure 3. (a) Raindrop sensor is connected to WeMos board, (b) Schematic diagram for raindrop sensor.

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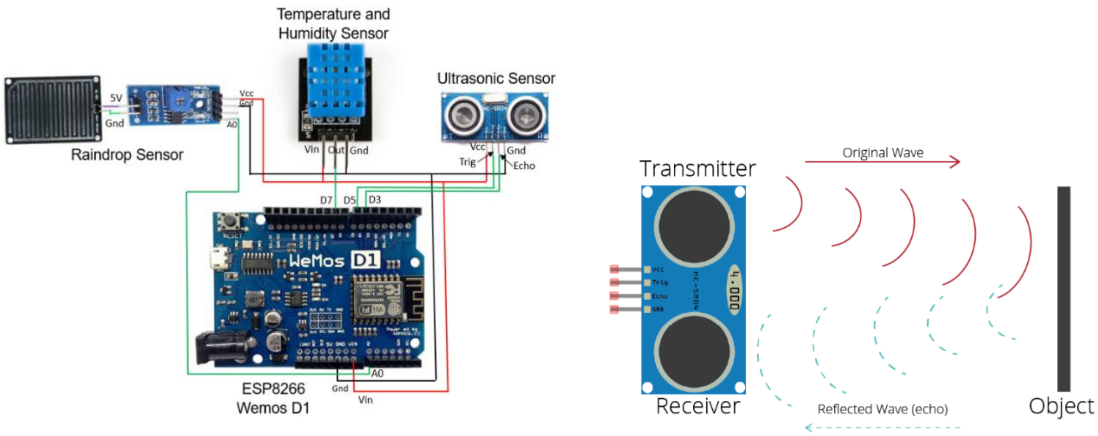
Based on Figure 4(a), the WeMos board supplies 5v to temperature, humidity, and ultrasonic sensors. Pin D7 is then used to link the Temperature and Humidity Sensor output pin to the WeMos board. The surrounding humidity is measured using a temperature and humidity sensor. Pin Trig and Pin Echo Ultrasonic Sensor are connected to the WeMos Board through the Pin D5 and D3. The ultrasonic sensor is used to sense the object, as shown in Figure 4(b). Figure 5 illustrates the connection between the buzzer and the WeMos Board. The buzzer warns the user if the flood level is dangerous.



(a) (b)

Figure 4. (a) Ultrasonic sensor and Temperature and Humidity Sensor are connected to ESP8266 WeMos D1, (b) Interfacing HC-SR04 Ultrasonic distance sensor

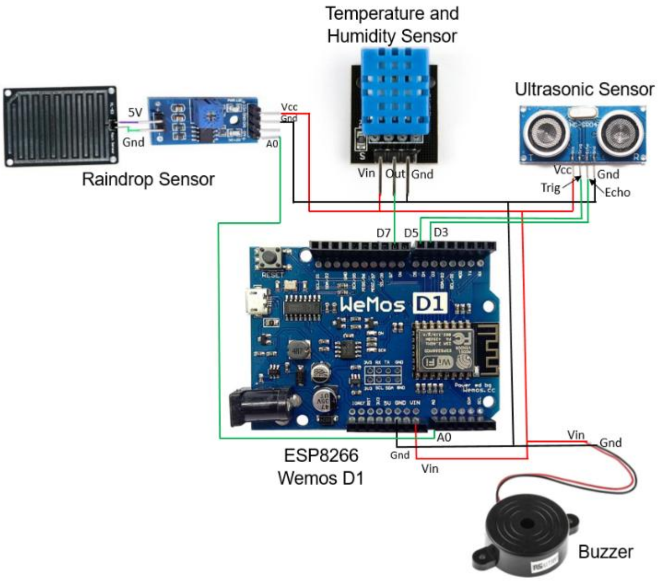


Figure 5. Buzzer is connected to the WeMos board

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2.3 Software Development

Figure 6 depicts the programming flow chart for the proposed system. The Raindrop sensor will detect the rain if the rain reading is more than 800, so there is no rain; if less than 800 is raining, it means rain; if less than 200 means heavy rain. Temperature and humidity sensors measure the temperature and humidity surrounding the environment.

The results count for temperature and will be displayed on the user's handphone through the Blynk IoT Application. The distance to the water's level is sensed using an ultrasonic sensor. If the distance between an ultrasonic sensor and the flood level is more than 50cm, it is normal, and no flood happens. If the distance is less than 50cm, the flood has reached a hazardous level, and the buzzer will alternately sound. If less than 10cm, the flood has reached a frightening level, the buzzer will continuously sound to notify nearby communities and concerned authorities of potential flood events. Users or significant rescue organizations like the National Disaster Management Agency (NADMA), National Security Council (JPAM), and Fire and Rescue Department (BOMBA) would receive the alert notice message and email through the IoT Blynk Application. This can help to ensure the communities are aware of the danger and can take appropriate action to protect themselves and their property.

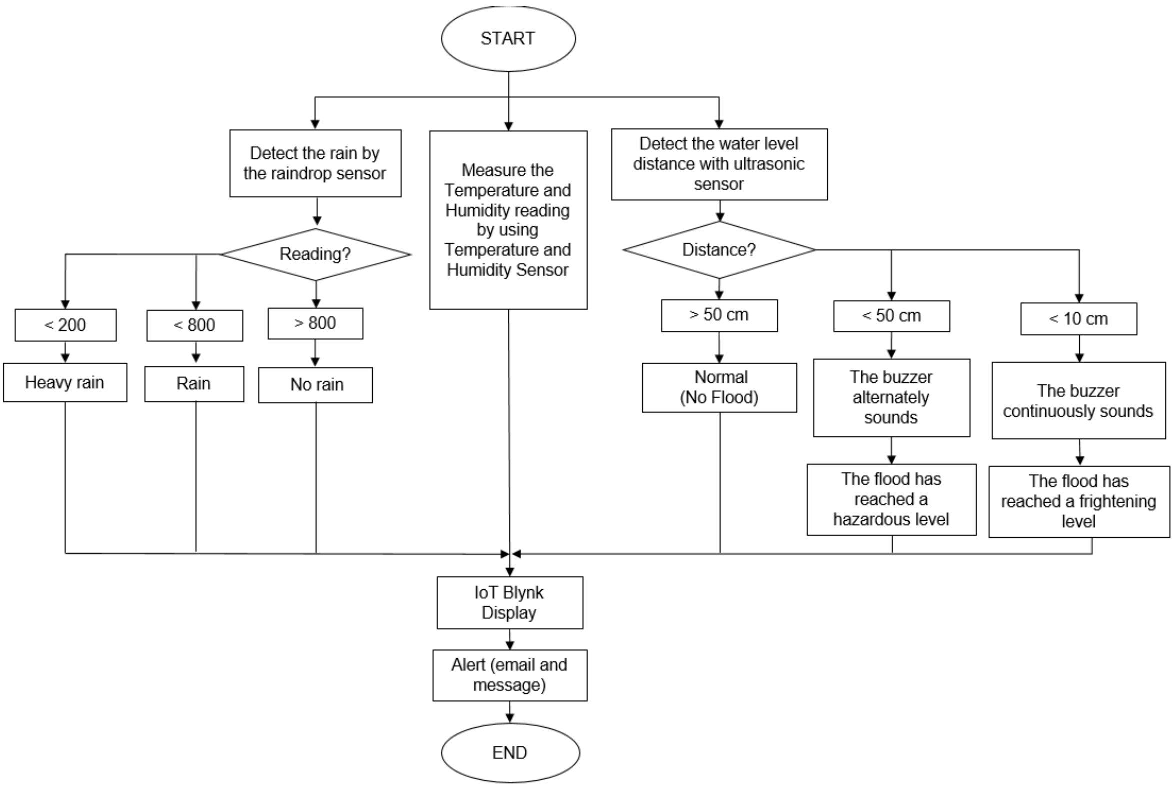

Figure 6. Programming flow chart

3. Results and Discussion

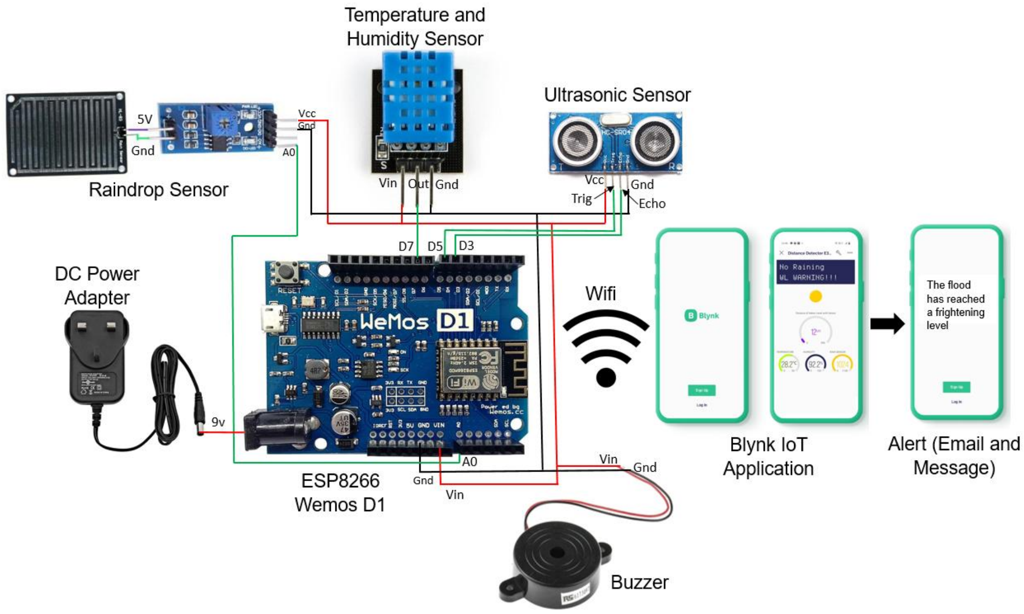

Figure 7. Schematic Diagram for IoT-Based Early Flood Detection and Monitoring System using Blynk Application

An IoT-based early flood detection and monitoring system constructed using the Blynk application is schematically shown in Figure 7. The ESP8266 Wi-Fi module is built into the Arduino-compatible WeMoS D1 board. The boards employ the amazing ESP8266 Wi-Fi chip rather than the ATMEGA chip used on normal Arduino boards. IEEE 802.11 enables microcontrollers to establish a 2.4 GHz Wi-Fi connection with the ESP8266 module. The module has the ability to process data, read from, and operate GPIOs. It encompasses the entire TCP/IP stack as well. The ESP8266 is the central CPU and Wi-Fi chip of the board; other integrated circuits are our UART USB and CH340. Based on ESP12e, the ESP8266 D1 R1 IoT board is an alternative to NodeMCU. The ESP8266 is the central CPU and Wi-Fi chip of the board; other integrated circuits are our UART USB and CH340. Based on the ESP12e IC, the ESP8266 D1 R1 IoT board is an alternative to NodeMCU. A second power adapter is also supplied, as well as a 3.3V regulator that allows the user to employ an external converter with up to 12V output. It consists of multiple Tx and Rx pin headers as well as a barrel jack for DC input. I2C communication uses digital pins D3, D4, D5, D6, and D7 in addition to SDA and SCL pins. Subsequently, there is an additional I2C connection pin that replicates D1 and D2. There is just one analogue input on the board.

Temperature and humidity sensors are inexpensive, sensitive electronic devices that detect, measure, and report moisture and air temperature. The proportion of moisture is visible to the greatest moisture at a given air temperature. A device that senses rain is called a raindrop sensor. It is composed of two modules: a control module that compares analogue readings and converts them to digital values, and a rain board that senses rain. The control module of the raindrop sensor is in communication with the rain board module. There are four output channels in the control module of the raindrop sensor. VCC has a 5 volt power supply connected to it. The ground is linked to the GND pin of the module. You can use the analogue pin or connect the D0 pin to the microcontroller's digital pin to get digital output. A microcontroller's A0 pin must be connected to the ADC pin in order to use the analogue output. The user can use any of the six ADC pins on the Arduino without the need for an ADC converter. Potentiometer, LN393 comparator, LEDs, capacitors, and resistors are all part of the sensor module. The pinout graphic above shows the parts of the control module. Copper rails, which function as a variable resistor, make up the rain board module. The resistance varies with the rain board's moisture content. To activate the HC-SR04 ultrasonic sensor, provide a 10μS High-level signal to its TRIGGER input pin. The gadget will then emit eight 40 KHz ultrasonic pulses. When these ultrasonic sound waves travel through the atmosphere, they are automatically reflected or bounced back to the receiver module if they come across an object or obstacle. If the module detects a returning signal, it will emit a HIGH pulse in the ECHO pin for the amount of time it takes the ultrasonic waves to return. Now, the obstacle's distance may be estimated using the period. If the ultrasonic sensor senses the flood level is in the middle level, the buzzer will alternately sound because the flood has reached a hazardous level, as shown in Figure 8 and Figure 9. If the ultrasonic sensor detects a distance of less than 10cm, the buzzer will continuously sound because the flood has reached a frightening level. The alert notification message and email will be sent to the users or the important rescue agencies through the Blynk Application, as shown in Figures 10 and 11.

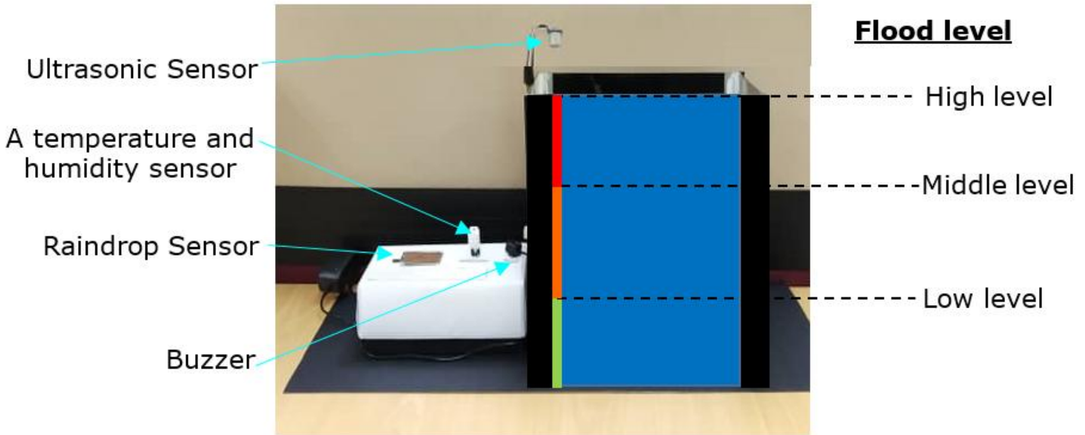

Figure 8. Front View for an early flood detection and monitoring system prototype

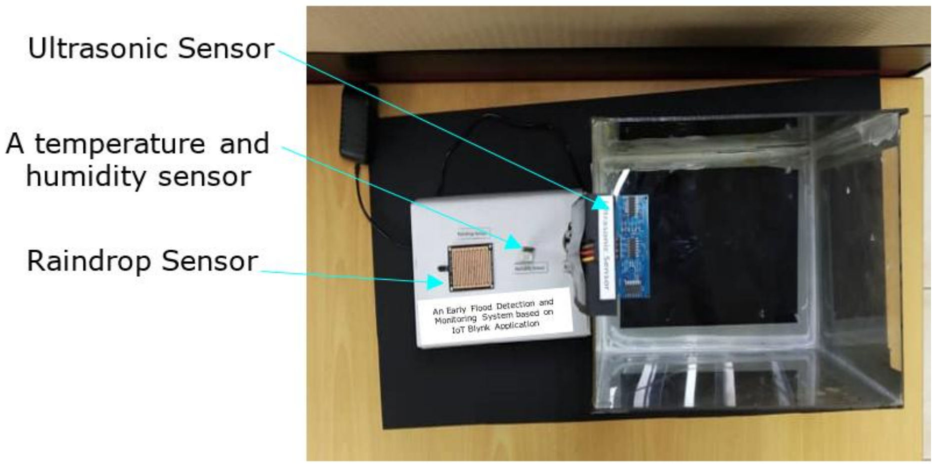

Figure 9. Top View for an early flood detection and monitoring system prototype

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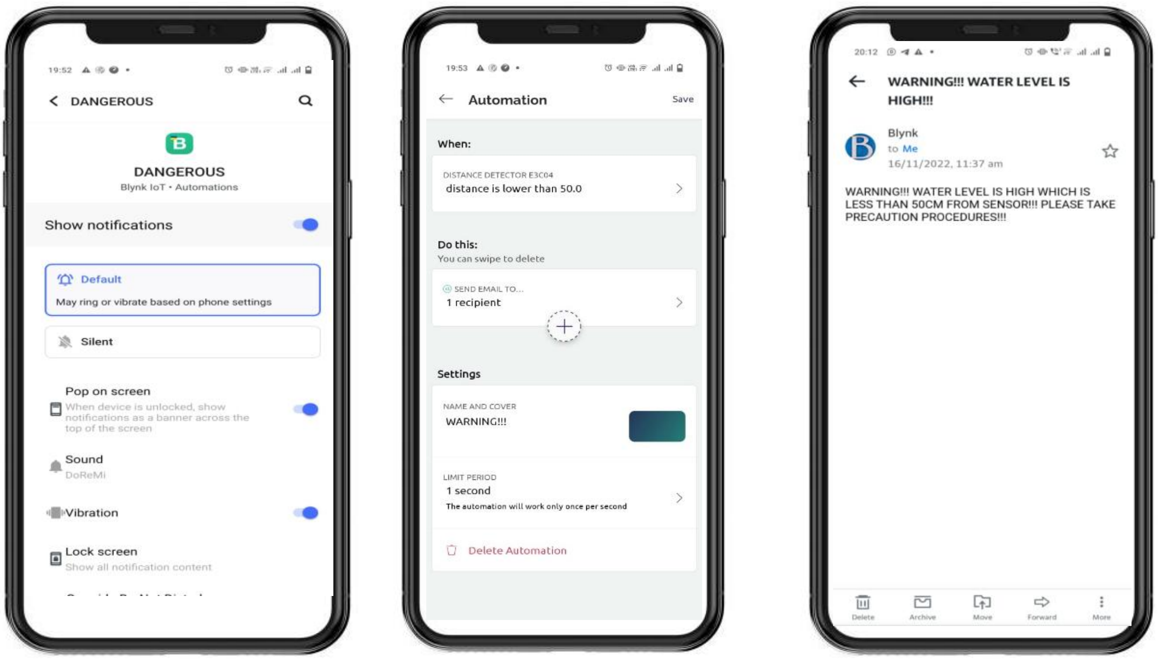
(a) No Raining, Safe (b) Raining, Warning! (c) Heavy Raining, Dangerous!

Figure 10. Result in IoT Blynk application



(a) Setting for alert message and email (b) Alert email

Figure 11. Notification (message or email)

The measurement outcomes of an early flood detection and monitoring system built on the IoT Blynk application are displayed in Table 1. The measurement results for temperature reading, humidity reading, rain status, and distance between an ultrasound sensor and flood level were displayed through the Blynk Application. The flood warning is divided into three levels depending on the measured data from the ultrasonic sensor. If the distance between an ultrasound sensor and the flood level is 56cm, the buzzer will not sound, and the Blynk application will not send the alert message to users. Suppose the distance between an ultrasound sensor and the flood level is 12cm. In that case, the buzzer will alternately sounds, Blynk application will send the alert message "Warning! The flood has reached a hazardous level to users or emergency agencies. If the distance between an ultrasound sensor and flood level" is 4cm, the buzzer will continuously sound to notify nearby communities and concerned authorities of potential flood events, and Blynk application will send the alert message "Dangerous! The flood has reached a frightening level" to users or rescue agencies. This innovative system can also detect rain accurately using the raindrop sensor.

Table 1. Results for Proposed System

Reading from Raindrop Sensor	Reading from Temperature and Humidity Sensor	Distance between the Ultrasound Sensor and the flood level	Buzzer	Alert (Message)	Alert (Email)
1024	Temperature:28.2°C Humidity: 61.3%	56 cm Low flood level	No	No (No Raining, Safe)	No
700	Temperature: 24.5°C Humidity: 92.2%	12 cm Middle flood level	Yes (Alternately sounds)	Yes (Warning! The flood has reached a hazardous level)	Yes
102	Temperature: 24.5°C Humidity: 92.3%	4 cm High flood level	Yes (Continuously sounds)	Yes (Dangerous! The flood has reached a frightening level)	Yes

4. Conclusion

In conclusion, an early flood detection and monitoring system with the Internet of Things (IoT) has been developed. This system can detect flood levels and send alert notification messages and emails to users or important rescue agencies through the Blynk Application. The flood warning is divided into three levels depending on the measured data from the ultrasonic sensor. With earlier alert notification, it is possible to avoid loss of property and loss of life in the local community, and emergency agencies can reach the flood area earlier to carry out rescue. This system can be improved using solar energy, especially in rural areas.

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